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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Power Plant

We, ROLLS-ROYCE LIMITED, a British company of Nightingale Road, Derby, Derbyshire, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns a power plant for a helicopter, and a helicopter provided therewith.

According to the present invention there is provided a power plant for a helicopter comprising a gas turbine engine having a shaft drivingly connected to a fan and to mechanical drive means for mechanically rotating a helicopter rotor, means being provided for increasing and decreasing the power absorbed by said fan whereby the power transmitted to said mechanical drive means is decreased and increased respectively.

The term "fan" where used in this specification is intended to include all air impellers, including propellers.

Preferably means are provided for feathering, or partially feathering said fan blades to thereby decrease the power absorbed by said fan.

The fan is preferably disposed within a duct.

In a preferred embodiment, said shaft is connected to said fan and to said drive means by gearing. Thus said shaft may drive an input gear wheel forming part of a reduction gear of which gear wheels carried by said fan and by said mechanical drive means also form part, said gear wheels being in meshing relationship with said input gear wheel and with each other.

The mechanical drive means may include a shaft on which said gear wheel is mounted, a free wheel drive being provided on said shaft. Preferably the shaft is driven by a free turbine of said gas turbine engine.

In a preferred arrangement, the gas turbine engine comprises a compressor, combustion equipment, and a turbine mounted in axial flow relationship, the gases which have passed through said turbine passing then through said free turbine. The compressor and turbine may be mounted on a common shaft, which is coaxial with said shaft.

Preferably some of the air passing through said fan blades passes into the intake of said compressor, the remainder by-passing said gas turbine engine. The by-pass ratio is preferably at least 3 to 1, and in a preferred embodiment is 4 or 5 to 1.

The invention also includes a helicopter provided with a power plant as set forth above. Two power plants may be provided, these being drivingly connected to two helicopter rotors by shafting and gearing. Preferably the helicopter is provided with aerofoil surfaces which are adapted to provide aerodynamic lift for the helicopter under forward flight.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which;

Figure 1 is an elevation of a helicopter in accordance with the present invention,

Figure 2 is a plan of the helicopter shown in Figure 1, and

Figure 3 is a part-sectional view of a power plant in accordance with the present invention, provided on the helicopter of Figures 1 and 2.

Referring to the drawings, a helicopter 10 is provided with two rotors 11, 12 mechanically rotated by shafts 13, 14 respectively. Shaft 13 is driven through a gear box 15 by a shaft 16. Shafts 14 and 16 are driven from a common gear box 17, drive to which is supplied by shafts 20, 21.

Shafts 20 and 21 are driven by two gas turbine engines 22, 23 mounted on stub wings 24, 25 of the helicopter. Further wings 26, 27 are mounted on the helicopter 10 for providing aerodynamic lift in forward flight.

The engines 22, 23 are identical in con-

[*Price 4s. 6d.*]

struction and engine 22 is shown in detail in Figure 3. The engine comprises a compressor 23, combustion equipment 24, two-stage turbine 25, two-stage free turbine 26 and jet pipe 27. Compressor 23 and turbine 25 are mounted on a common shaft 28. Free turbine 26 is mounted on a shaft 30 which is coaxial with shaft 28. Shaft 30 is provided, at its forward end, with an input gear wheel 31 which forms part of a reduction gear 32 of which a gear wheel 33 and a gear wheel 34 also form part. Gear wheels 31, 33 and 34 are in meshing relationship.

Gear wheel 33 is fixed to shaft 20, which forms part of the mechanical driving means for rotors 11 and 12, and gear wheel 34 is attached to a hub 35 of a ducted fan 36. Ducted fan 36 comprises blades 37 disposed within a fairing 40 which is supported by inlet guide vanes 41 and struts 42 from the engine. Shaft 20 passes through a strut 42 and includes a free wheel device 43.

Air entering the engine passes through the ducted fan 36, most of the air then passing to atmosphere, by-passing the engine 22. However part of the air from ducted fan 36 (E.G. one fifth or one quarter) passes through compressor 23, combustion equipment 24, turbine 25, free turbine 26 and through jet pipe 27 to atmosphere. The gases passing through turbine 26 drive the turbine and thus drive compressor 23. Gases passing through free turbine 26 drive this free turbine and thus rotate shaft 30 and input gear wheel 31.

Thus, in operation, gear wheel 31 is rotated at all times, and thus gear wheels 33 and 34, and thus shaft 20 and ducted fan 36, are rotated at all times. Means, not shown, are provided for feathering the blades 37. When these blades are feathered, the power absorbed by the ducted fan 26 is a minimum, and a major portion of the power from input gear wheel 31 will be taken by shaft 20, for driving the helicopter rotors. When the blades 37 are unfeathered, the ducted fan 36 will absorb power, and the power transmitted to the helicopter rotors will be reduced accordingly.

For take off, landing and hovering conditions, a major portion of the power output from free turbine 26 is required by rotors 11 and 12, to provide vertical lift forces. Thus the blades 37 are feathered in these conditions. Since, in these conditions, little or no forward flight is required, the power reduction from the forward propulsion engines 22, 23, is of no consequence.

For forward flight, the blades 37 are unfeathered. As the blades are progressively unfeathered, the power output from engines 22, 23 will increase, to provide forward propulsion, and the speed of rotation of rotors 11 and 12 will be reduced. The loss in lift due to reduction in the speed of rotation of rotors 11 and 12 will be compensated for by the increase in lift provided by wings 26 and 27, as the helicopter moves forward.

At the top forward speed of the helicopter, which may, for example, be of the order of 250 m.p.h., the rotors 11 and 12 are arranged to rotate at 60% of their speed of rotation needed in hover conditions. Thus the rotors are off-loaded, since lift is provided by the wings 26, 27, and, at 60% rotational speed, the rotors will be rotated sufficiently to offset the anti-rotational drag losses which will be produced in these conditions.

Since the rotors are mechanically driven from the engines 22, 23, no air ducts are required in the rotor blades to feed tip jets (as would be required for purely jet propelled rotors), and thus the "thickness/chord" ratio of the outer section of the blades may be kept very low, to thereby reduce drag. Again, by using mechanically driven rotors, the noise of the helicopter can be kept low, since the noise of 'tip jets' is eliminated.

If the engines 22, 23 are designed to provide, say, 160% more power than that required in hover conditions, such that speeds of the order of 250 m.p.h. may be achieved, then a particularly safe helicopter will be provided, since the helicopter will still be able to hover even if one of its two engines failed.

It will be appreciated that many variations of the present arrangement may be effected. Thus the ducted fan 36 could be mounted at the rear of the engine 22, or could be disposed anywhere along its length e.g. the blades 37 could form extensions of the blades of the free turbine 26. Again, the shroud 40 could extend over the whole length of the engine 22, terminating adjacent the downstream end of the jet pipe 27. Also, the by-pass ratio of the power plant need not be 3 or 4 to 1, as suggested above, but could be greater than this e.g. 5 to 1 or higher.

It will be appreciated that a ducted fan is not the only air impeller which may be used with the present arrangement. The fan need not be disposed within a duct and propellers may be used in place of a fan.

WHAT WE CLAIM IS:—

1. A power plant for a helicopter comprising a gas turbine engine having a shaft drivingly connected to a fan and to mechanical drive means for mechanically rotating a helicopter rotor, means being provided for increasing and decreasing the power absorbed by said fan whereby the power transmitted to said mechanical drive means is decreased and increased respectively.

2. A power plant as claimed in claim 1 wherein means are provided for feathering, or partially feathering said fan blades to thereby decrease the power absorbed by said fan.

3. A power plant as claimed in claim 1 or 2 wherein said fan is disposed within a duct.

4. A power plant as claimed in any pre-

ceding claim wherein said shaft is connected to said fan and to said drive means by gearing.

5. A power plant as claimed in claim 4 wherein said shaft drives an input gear wheel forming part of a reduction gear of which gear wheels carried by said fan and by said mechanical drive means also form part, said gear wheels being in meshing relationship with said input gear wheel and with each other.

6. A power plant as claimed in claim 5 wherein said mechanical drive means includes a shaft on which said gear wheel is mounted, a free wheel drive being provided on said shaft.

7. A power plant as claimed in any preceding claim wherein said shaft is driven by a free turbine of said gas turbine engine.

8. A power plant as claimed in claim 7, wherein said gas turbine engine comprises a compressor, combustion equipment, and a turbine mounted in axial flow relationship, the gases which have passed through said turbine passing then through said free turbine.

9. A power plant as claimed in claim 8 wherein said compressor and turbine are mounted on a common shaft, which is coaxial with said shaft.

10. A power plant as claimed in claim 7 or 8 wherein some of the air passing through said fan blades passes into the intake of said compressor, the remainder by-passing said gas turbine engine.

11. A power plant as claimed in claim 10 wherein the by-pass ratio is at least 3 to 1.

12. A power plant as claimed in claim 11 wherein the by-pass ratio is 4 or 5 to 1.

13. A power plant substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

14. A helicopter provided with a power plant as claimed in any preceding claim.

15. A helicopter provided with two power plants as claimed in any preceding claim, the power plants being drivingly connected to two helicopter rotors by shafting and gearing.

16. A helicopter as claimed in claim 14 or 15 provided with aerofoil surfaces which are adapted to provide aerodynamic lift for the helicopter under forward flight.

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980608 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig. 1

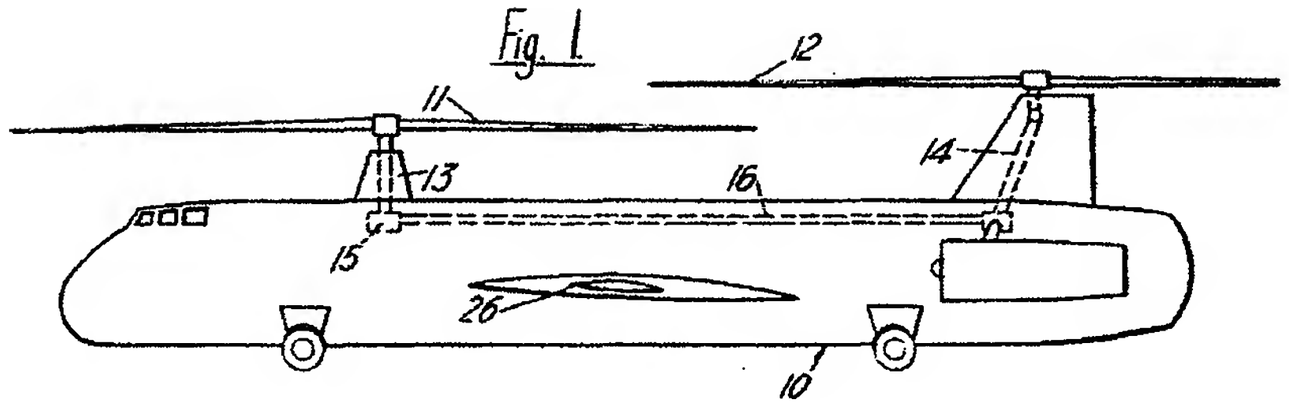

Fig. 2

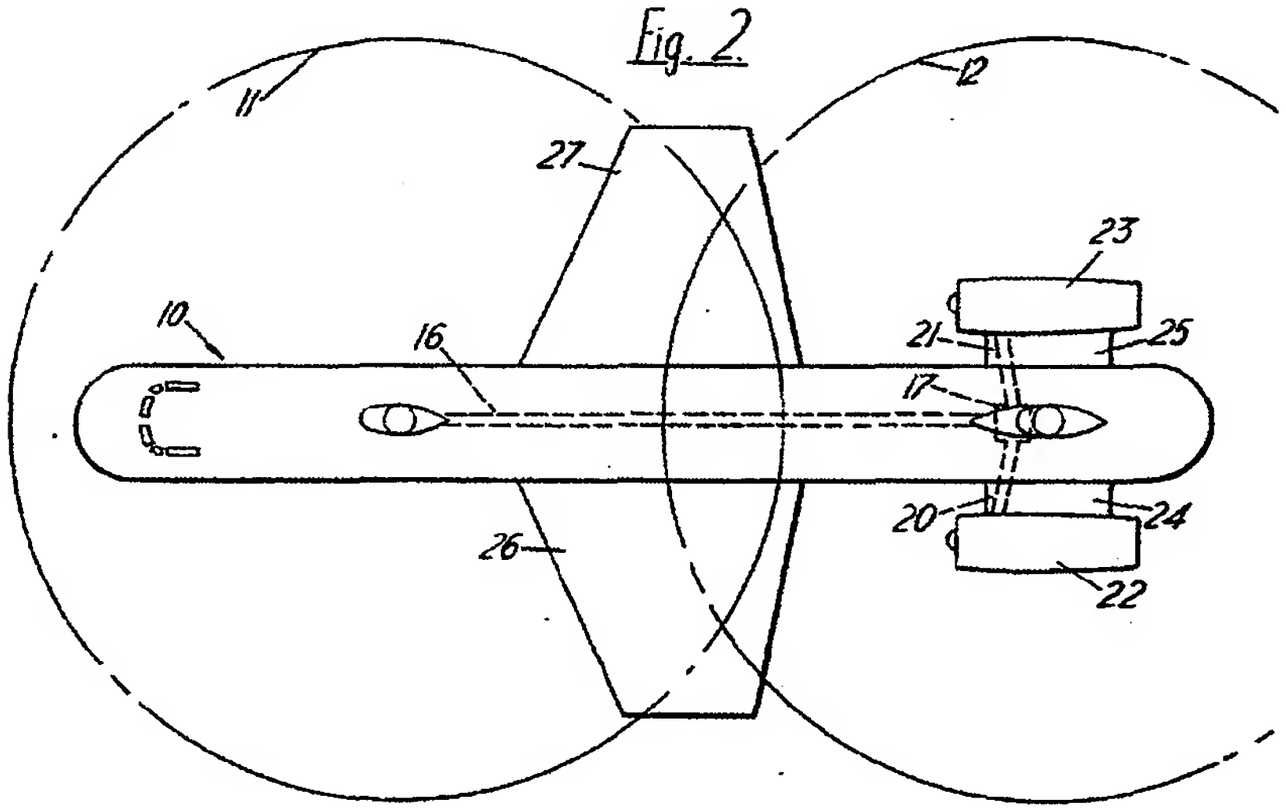

Fig. 3